91602
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ontario hydro
research division

To: Mr. G.E. Fraser
Manager, Distribution Operations
Distribution Systems Division
U6A6

EVALUATION OF TVI EQUIPMENT

G.K. Hatanaka

In April 1987, the DoC will no longer perform the task of locating power line TVI noise sources. Ontario Hydro will assume responsibility for the work and will require suitable instrumentation. An earlier Research Report No 82-70-K recommended several devices. Tunable field strength meters used with directional antennae were not considered in that study. This report describes recent tests on several tunable field strength meters and some new TVI devices that have recently come onto the market. Results are summarized and recommendations are given for suitable TVI instrumentation for Regional use by Hydro personnel.

1. Introduction

Over the years the Department of Communications has indicated that it will discontinue its service of locating television interference (TVI) sources on power lines and transfer the responsibility to Ontario Hydro. This situation has been anticipated for quite some time and was the reason for an earlier study to recommend suitable instrumentation for the Regions to perform this work. This is covered in Research Report 82-70-K/1/. Although the DoC have reduced their effort they have maintained considerable support up to this time. In addition the Electrical Research Department has provided assistance in some of the more difficult cases. For this reason, Hydro involvement has grown slowly and there is only a limited number of TVI devices presently being used by Regional personnel.

It is now apparent that in April of 1987 the DoC will no longer do this work. Ontario Hydro Regional personnel will perform the task of locating TVI sources. Suitable instrumentation is therefore required.

job	file	date	report no
18-182-240	816.22	February 3, 1987	86-363-K

At the request of the Distribution Operations Department, Research has evaluated several new devices for recommended use. The study included tunable field strength meters which were not considered in the earlier study and new instruments not previously available. The instruments to be evaluated were identified by the Distribution Planning and Design Department. In some tests these were compared to existing devices recommended in the earlier report. The results of the present study and further recommendations for suitable instrumentation are given in this report.

2. Summary of Tests

The tests were performed in both the laboratory and in the field on the distribution test line at the Kleinburg Test Facility using artificially generated noise sources. These tests were expedient, given a limited time frame to complete the study but they cannot replace actual investigations on real power line noise sources on practical TVI problems. Nevertheless, the test method provides a good indication of the performance that can be expected and the suitability of each device for use in the field by Regional personnel.

The key features for suitable TVI locating instrumentation are: performance, ease of use, portability, and affordable cost. The evaluation focussed on these criteria.

Performance is based on the probability of accomplishing a specified task for which the instrument was intended. TVI location consists of the following basic tasks or steps:

i) locating the general area of the noise source,
ii) identifying the structure with the noise source,
iii) pinpointing the individual noise defect on the structure.

Suitable instrumentation is required for each of these tasks. Each task usually involves different pieces of equipment. Each instrument is designed specifically for just one of these tasks although its use can sometimes extend to other tasks.

3. Laboratory Tests

Laboratory tests were performed only on the tunable field strength meters (FSMs).

FSMs are tunable voltmeters that operate over the range of frequencies that are covered by TVI sources the vhf and uhf bands. The ability of a FSM to detect TVI sources depends on its sensitivity to power line noise. The ability to locate the sources depends on the properties of the antenna used in conjunction with it.

The sensitivity of the meter is a function of the bandwidth, the type of detector (such as peak or average) and the internal noise floor of the instrument.

There are any number of FSMs on the market. Special, sophisticated instruments such as the Singer/Ailtech NM37/57A Field Intensity/Electromagnetic Noise Meter and the Rohde & Schwarz ESVP Test Receiver used extensively by the Research Division are excellent instruments but are not portable and are very expensive ($40k to $60k).

The following tunable meters selected for testing are all portable and considerably cheaper:

i) Rohde & Schwarz Miniport receiver, Model EB100, 20 - 1000 MHz.
ii) Sadelco FS 3D-VU Signal Level Meter, approx 54 to 890 MHz (TV bands).
iii) Texcan Spectrum 700 Signal Level Meter, 5 - 600 MHz.
iv) Micro Tech Model 700 Interference Locator, 0.5 - 250 MHz.

Power line noise is impulsive and repetitive in nature. The repetition rate can vary over a wide range. CEA Report 102D201 /2/ indicates typical rates of up to 5000 pps for gap sources and 50,000 pps for insulator sources. For TVI work the FSM should have sufficient sensitivity to detect most normal TVI sources encountered in the field. This aspect was tested in the laboratory by simulating power line noise from a variable repetition rate impulse generator (Ailtech Model 533X-11).

Figure 1 shows the sensitivity of the instruments to repetitive impulses. The graph shows the pulse amplitude required for each meter to just detect the noise at different repetition rates. The results are compared to the quasi-peak detector in a 100 kHz bandwidth on the Ailtech NM37/57A. This is a commonly used detector for the measurement of power line noise and can be used as a benchmark.

The Micro Tech 700 is comparable to the NM37/57A quasi-peak, 100 kHz bandwidth except at low repetition rates. The Sadelco has an overall lower sensitivity, while the Texscan has a considerably lower sensitivity. The Rohde & Schwarz has good sensitivity at high pulse repetition rates but it is very poor at the lower rates. The NM37/57A peak detector in a 1 MHz bandwidth which is used by Electrical Research to detect noise sources in TVI investigations exhibits the best sensitivity over the entire range of pulse repetition rates.

The sensitivity is a function of the detector response, the bandwidth and the internal noise of the meter. The internal noise level at the front end of the meter sets the lower limit of measurability. The ability to detect impulsive power line noise above the random internal noise increases with wider instrument bandwidths. The type of detector determines how the sensitivity varies with pulse repetition rate.

Figure 2 shows the detector response of the tested meters to repetitive pulses. Ideally, the response should be equal at all repetition rates. This is true for the peak detector.* The detector response for the various meters are referenced to the NM37/57A peak detector and 1 MHz bandwidth except for the Micro Tech which uses a scale marked in dc mA. Its response is referred to a 1 dc mA scale reading. The quasi-peak detector on the NM37/57A is also shown for comparison.

The results show that the response of all the detectors falls off at low repetition rates. The Sadelco detector is specified by the manufacturer as quasi-peak and can be seen to have a response similar to the NM37/57 quasi-peak response.

The ability of the FSMs to locate noise sources depends on the properties of the antennae used with them. All except the Texscan were evaluated in the field tests.

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*Note: Other detectors are more suitable for assessing the actual interfering effect that the noise may have on the TV picture quality. However, for location of noise sources, peak detection is best.

4. Field Tests

TVI equipment tested in the field is shown in Figure 3.

Field tests were performed to evaluate the ability of the various devices to locate or pinpoint noise sources. The FSMs require an antenna to locate the general area of the source or identify the source structure. This is generally done with a directional antenna by approaching in the direction of the highest noise levels. A non directional antenna can also be used using proximity techniques to narrow down the location of the source to a small area or pole. The operator closes in on the source by gradually reducing the sensitivity by either tuning to higher frequencies where the noise levels are lower or by reducing the efficiency of the antenna. Devices used to pinpoint the noise sources use the same principles.

The tests were performed at the Kleinburg Test Facility. A short distribution test line, 4 spans in length had been built as part of a CEA project to study TVI on distribution lines/3/. This was used to check the ability of equipment to locate the general area of the source and identify the source structure. An artificial gap source consisting of two isolated tungsten electrodes and a capacitively charged metallic sphere was set up on the center phase near a pole in the middle of the line section. A gap spacing of 0.205 mm was set to produce noise characteristics typical of a severe source that might be expected on an operating line. The same source with a gap spacing of 0.102 mm was set up on a short cross arm pole top structure set up in the yard (Figure 4) to check out the pinpointing devices. A noisy pin-type insulator was also used as a noise source on these tests. The insulator noise results from sparking between a loose tie wire and the porcelain surface due to insufficient conductivity of the Q-glaze.

The performance of the devices is summarized below.

5. Summary of TVI Equipment Performance

Sadelco FS 3D-VU Signal Level Meter, 54 to 890 MHz (TV Bands)

This is a tunable signal level meter designed primarily for measuring TV signal strengths. However, it has a quasi-peak detector which makes it suitable for power line noise detection as well. It worked well with both the Radar Engineers DDF Locator and Rohde & Schwarz HE100 Active Directional Antenna to localize the area of the noise source and locate the source structure.

It is easy to use and has a large easy-to-read scale. It is light (3.2 kg), battery operated (14 hrs on a complete charge), portable and appears to be fairly rugged. It has recorder and scope outputs which give it added flexibility. Accuracy of $\pm$ 1 dB is maintained over a temperature range of -17° to 38° C. It would benefit from a volume control and a tuning dial with frequency markings rather than just channel numbers. The shape of the meter is a bit awkward for using comfortably at hip level.

Approximate Cost: $1,110 Cdn.

Recommendation: suitable

Texscan Spectrum 700 Signal Level Meter, 5 to 600 MHz

This is another portable, lightweight (3.6 kg), battery operated, signal level meter used primarily for the measurement of TV signals. It comes with a good carrying case and strap. The operating temperature range is from -17° to 55° C. The size and weight (5.9 kg) are good but the detector response is not suitable for TVI work. It was not tested in the field.

Approximate Cost: $2,740 Cdn.

Recommendation: not suitable

Micro Tech Model 700 Interference Locator, 0.5 to 250 MHz

This is an instrument specifically designed for location of power line noise sources. It comes with a complement of 6 antennae covering its tunable frequency range. It operates 8 hours continuously on battery and is reasonably portable weighing about 5 kg including batteries.

The video output was not particularly useful for displaying noise pulses on an oscilloscope. Although the lab tests indicated it should have adequate sensitivity, we had no success at detecting the noise source on the test line using both the 6 inch loop (17-34 MHz) and the Model 544 folded dipole with single element reflector (200 MHz). Although power line noise was audible on the speakers we could not make any sense out of the readings.

Overall, we found the Model 700 unsatisfactory. Use of the sensitivity adjustment is confusing. Because the attenuator settings are not given in known increments and the scale reading is marked in dc mA, the noise and signal readings are only relative which reduces the versatility of the instrument.

Approximate Cost: $2,380 Cdn.

Recommendation: not suitable

Rohde & Schwarz Miniport Receiver EB100, 20 to 1000 MHz

This is a portable, microprocessor controlled, battery operated (4 hours) receiver. It is well built and very easy to use. The temperature range is from -10° to 55° C. The size and weight (3 kg without battery) are good. The frequency is displayed on a 6 digit LCD and is set from a keypad or an excellent tuning knob. Generally, it is a very good instrument and clearly a cut above the other meters tested in terms of quality and workmanship. However, the cost is considerably higher and is definitely a limitation for this application.

The EB100 is designed primarily to be used with an active antenna such as the HE100 for direction finding of narrow band signal sources. The small meter scale and dectector response are adequate for this type of emission but totally unsatisfactory for power line noise. The EB100 was used successfully with the HE100 antenna to locate the noise source but this was more representative of the performance of the antenna rather than the receiver.

Approximate Cost: $20,230 Cdn

Recommendation: not suitable

Rohde & Schwarz Active Directional Antenna HE100, 20 to 1000 MHz

This is a lightweight (about 1 kg), active hand held direction finding (DF) antenna that covers a wide range of frequencies with three RF antenna modules that have a cardioid pattern in both the horizontal and vertical planes. The modules conveniently snap easily in and out of the pistol type grip that houses a low noise amplifier for increased sensitivity. The HE100 operates over a wide temperature range, from -30° to 50° C. The HE100 is well built and appears to be fairly robust. It is meant to be used with a compact portable receiver such as the EB100.

The HE100 proved to be very directional and extremely easy to handle, clearly the best hand held antenna that we have used. It worked well with both the EB100 miniport receiver as well as the Sadelco FS 3D-VU meter. Antenna factors are provided so that the meter reading can be converted to field strength in dB above 1 μV/m. The cost may seem high compared to other directional antennas but its performance in the field should pay for it after only a few TVI investigations.

Approximate Cost: $3,703 Cdn

Recommendation: preferred

Radar Engineers DDF Locator Model 237, 210 and 500 MHz

This is a defect direction finding (DDF) locator that is designed specifically for power line noise sources. It consists of a combination of an extendible VHF dipole for locating the general area of the source and an 8 element UHF yagi antenna for identifying the source structure. A lightweight amplifier and speaker is mounted in a small case to the antenna boom. The DDF locator is used in conjunction with a standard field strength meter.

The DDF locator exhibited fair directionality and worked well with the Sadelco FS 3D-VU signal level meter. Although it is lightweight (1.4 kg), the hand grip is placed too far forward in the boom which makes continuous operation tiring on the arm. The antenna elements tend to get in the way and catch on things. This is a bit annoying. Generally, however, it performed satisfactorily.

Approximate Cost: $1,300 Cdn

Recommendation: suitable

Radar Engineers Hotstick Line Sniffer Model 247, Ultrasonic and VHF modes

The Hotstick Line Sniffer is specifically designed to detect and pinpoint defect source components after the noisy structure has been identified. It is a hotstick device to be used by a line crew. It is intended for distribution lines but can be used on transmission lines with a hotstick extension. It incorporates a short extendible rod antenna that controls the sensitivity of the VHF noise detection of sources on the pole structure and an ultrasonic detector for more precise pinpointing. It does not use a directional dish but a short hollow tube as an ultrasonic probe. There is a single control knob for volume and sensitivity. The hollow hotstick acts as a speaker tubing. An accessory whip antenna provides limited capability for locating the source structure at ground level.

The Hotstick Line Sniffer worked well. Both the VHF and ultrasonic probe pinpointed the gap and the insulator noise sources on the cross arm pole top structure. This is important as some severe TVI sources such as the gap source used in the study have undetectable ultrasonic noise levels whereas other sources such as the insulator used in the study generate very loud acoustic noise but very low levels of VHF noise. The accesssory whip was also capable of identifying the source structure on the short test line. However, it cannot be used to pinpoint sources from ground level like the ultrasonic detector and directional dish. Overall it appears to be a useful device at a reasonable cost.

Approximate Cost: $1,000 Cdn

Recommendation: suitable

6. **Previously Tested Devices**

There are several devices which were previously recommended in the earlier study described in Research Report 82-70-K/1/. Several of these are presently being successfully used by the Regions and the Research Division and are considered to be useful devices. These include the following:

International Nuclear Corporation TNL-2. A directional locator operating in the low VHF band (26-31 MHz, just below GRS, "Citizen's Band") suitable for localizing the general area of the noise source, usually to within one of several adjacent poles.

Approximate Cost: $1,048 (in 1982)

Sprague, Micro Tech RFI Gun, Model 1010/1020. A directional UHF (470-806 MHz) locator for identifying the source structure and the general area of the noise source on the structure. The rifle stock on the Model 1010 which we tested may alarm the general public and police. Therefore, the Model 1020, which is identical except for the rifle stock, may be preferred.

Approximate Cost: $1,295 (in 1982)

HP Ultrasonic Translator Detector, Model 4914A, Ultrasonic Reflector, Model 18043A, Headset, Model 18017A. A directional acoustic (36-44 kHz) device for pinpointing specific hardware.

Approximate Cost: $1,521 (in 1982)

Sprague, Micro Tech "Little Snoop" Interference Locator. An RF broadband, non-directional, "near field" detector, hand-held or hot stick mounted for pinpointing specific hardware.

Approximate Cost: $250 (in 1982)

Except for the TNL-2 these devices were also field tested in conjunction with the devices selected for the present study. The performance was found to be good and reconfirmed the recommendations of the earlier work.

7. Conclusions and Recommendations

Research Report 82-70-K recommends several TVI location devices for Regional use. Several of these are presently being used successfully by the Regions and Research Division. They are considered to be useful devices.

The investigation leading to the above report did not consider the use of tunable field strength meters. In addition, new devices have come onto the market. Some of these have been identified and several instruments have been recently evaluated and compared to the existing equipment.

The location of TVI sources on power lines requires three basic steps:

i) locating the general area of the source,
ii) identifying the source structure,
iii) pinpointing the individual noise component.

Suitable instrumentation is required to accomplish each of these tasks.

Based on the results of the recent study and the earlier work, the recommendations are given in Table 1 for equipment to be used by the Regional personnel to handle TVI investigations in the field.

8. Acknowledgements

I would like to thank Mr. D. Jendek of Planning and Design and Mr. C. Altomare of Distribution Operations for their useful information and Mr. D.R. Goldthorpe of Electrical Research for his assistance in performing the tests.

Approved:

A.F. Baljet
Manager
Electrical Research Department

Submitted:

G.K. Hatanaka
Engineer
System Studies Section

GKH:td

References

1. G.K. Hatanaka,"TVI Instrumentation for Regional Use". Research Report No 82-70-K, March 18, 1982.

2. G.K. Hatanaka, "Power Line TVI Measurement Parameters". CEA Report No 102 D 201, March 1984.

3. CEA Project 205 D 406 "TV Intereference Study on Distribution Test Line". Results to be Published.

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HP Ultrasonic Translator Detector, Model 4914A, Ultrasonic Reflector, Model 18043A, Headset, Model 18017A. A directional acoustic (36-44 kHz) device for pinpointing specific hardware.

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Manager
Electrical Research Department

Submitted:

G.K. Hatanaka
Engineer
System Studies Section

GKH:td

References

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2. G.K. Hatanaka, "Power Line TVI Measurement Parameters". CEA Report No 102 D 201, March 1984.

3. CEA Project 205 D 406 "TV Intereference Study on Distribution Test Line". Results to be Published.

Table 1

Recommended Instrumentation for the Location of Television Interference (TVI) Sources

Recommended for: 1. Locating the general area of the source

Preferred: R&S HE100 Active Directional Antenna and Sadelco FS 3D-VU Signal Level Meter. (Cost approx: $5K)

Suitable: Radar Engineers DDF Locator Model, 237 and Sadelco FS 3D-VU Signal Level Meter. (Cost approx: $2.3K)

Acceptable: International Nuclear Corp. TNL-2. (Cost approx: $1K in 1982)

Recommended for: 2. Identifying the source structure

Preferred: R&S HE100 Active Directional Antenna and Sadelco FS 3D-VU Signal Level Meter. (Cost approx $5K)

Suitable: Radar Engineers DDF Locator, Model 237 and Sadelco FS 3D-VU Signal Level Meter. (Cost approx: $2.3K)

Suitable: Micro Tech RFI Gun, Model 1010/1020. (Cost approx. $1.3K in 1982)

Recommended for: 3. Pinpointing the individual noise components

Preferred: HP Ultrasonic Translator Detector, Model 4914A, Ultrasonic Reflector Model 1804A, Headset, Model 18017A (Cost approx: $1.5K in 1982) together with
Micro Tech "Little Snoop" Interference Locator. (Cost: $250 in 1982)

Suitable: Radar Engineers Hotstick Line Sniffer, Model 247. (Cost approx: $1K)

Note: Manufacturers or distributors of TVI Instrumentation are listed in the Appendix.

APPENDIX

Instrument Manufacturers

TNL-2 Locator

International Nuclear Corporation
608 Norris Avenue
Nashville, Tennessee
USA 37204

Model 700 Interference Locator

Model 1010/1020 RFI Gun

Little Snoop Locator

Micro Tech Manufacturing Ltd
703 Plantation Street
Worchester, Mass
USA 01605

Ultrasonic Detector and Reflector

(Formerly manufactured by Hewlett-Packard)
Communications Technology
20585 Rue Union, Suite 1560
Montreal, PQ H3A 2C3
(514) 845-5833

Sadelco FS 3D-VU Signal Level Meter

Radar Engineers DDF Locator Model No 237

Radar Engineers Hotstick Line Sniffer Model No 247

Wales & Associates, Inc
5105 88th Street NE
Marysville, Washington
USA 98270
(206) 659-5224

Rohde & Schwarz Miniport Receiver Model EB100

Rohde & Schwarz Active Directional Antenna Model HE100

Rohde & Schwarz Canada
25E Northside Rd
Nepean, Ontario K2H 8S1
(613) 829-3944

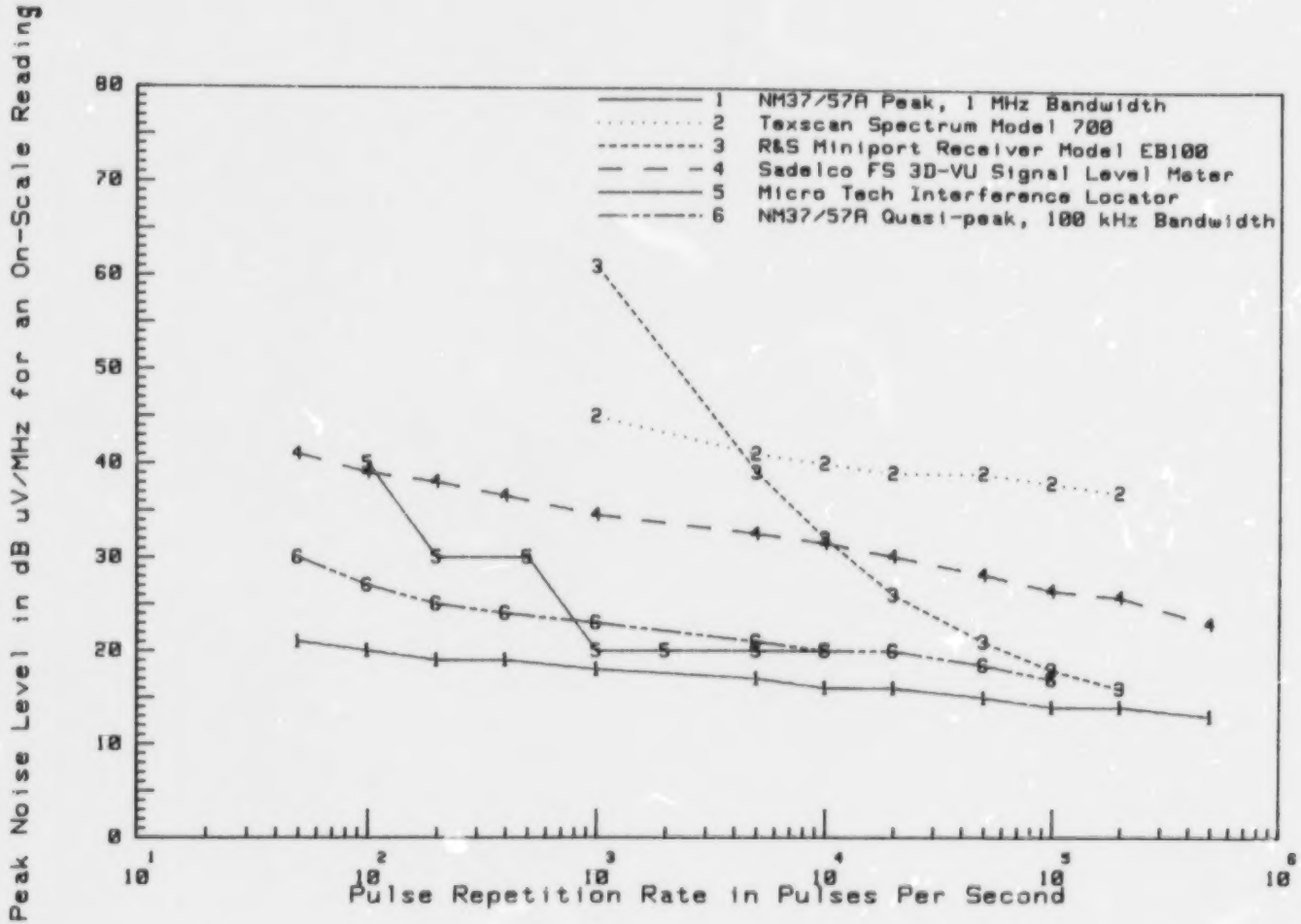


Figure 1 Meter Sensitivity to Repetitive Noise Pulses

Pulses at repetition rates of less than 1000 pps could not be measured on the R&S and Texscan at greater than 70 dB.

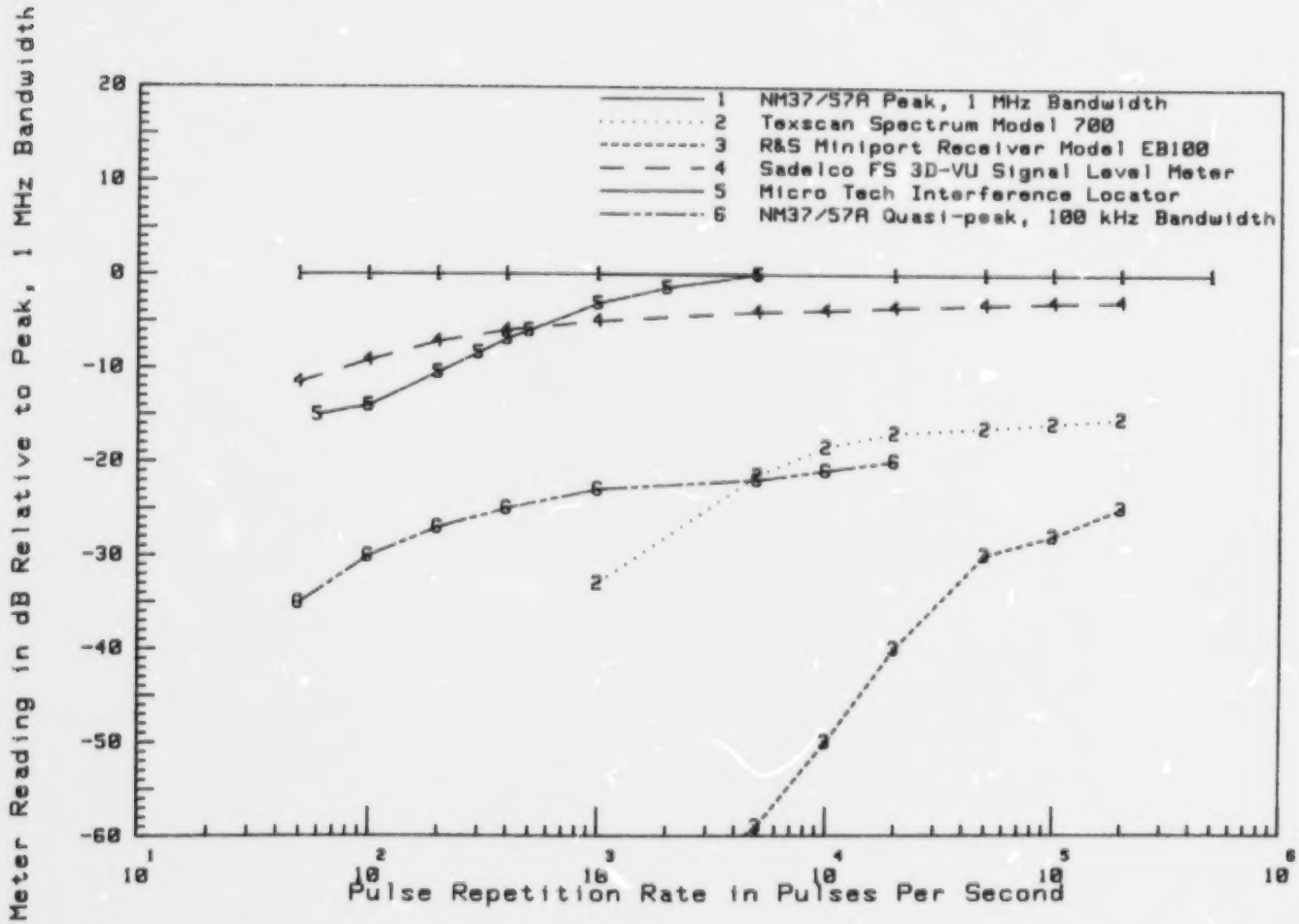
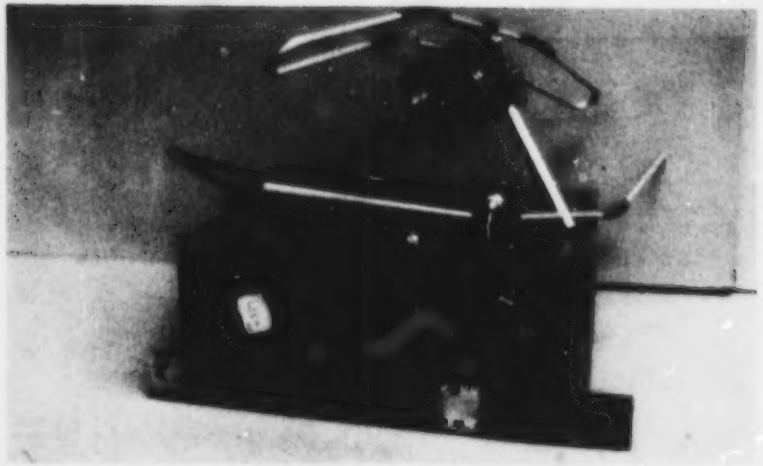
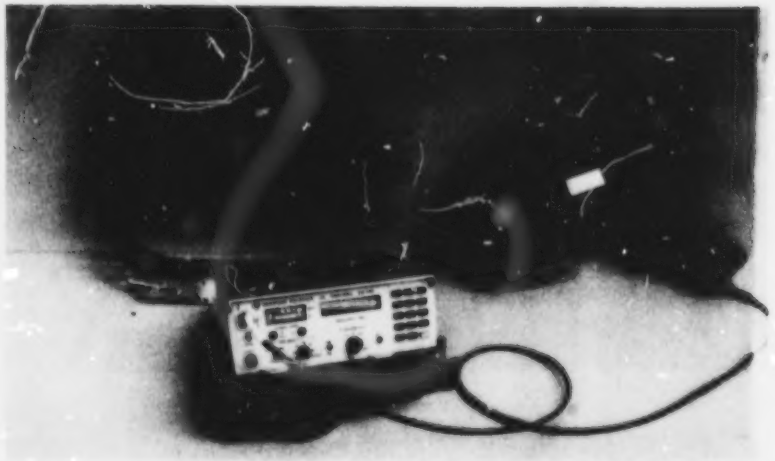


Figure 2 Meter Response to Repetitive Noise Pulses

Note: Micro Tech values are relative to 1 dc mA scale reading.

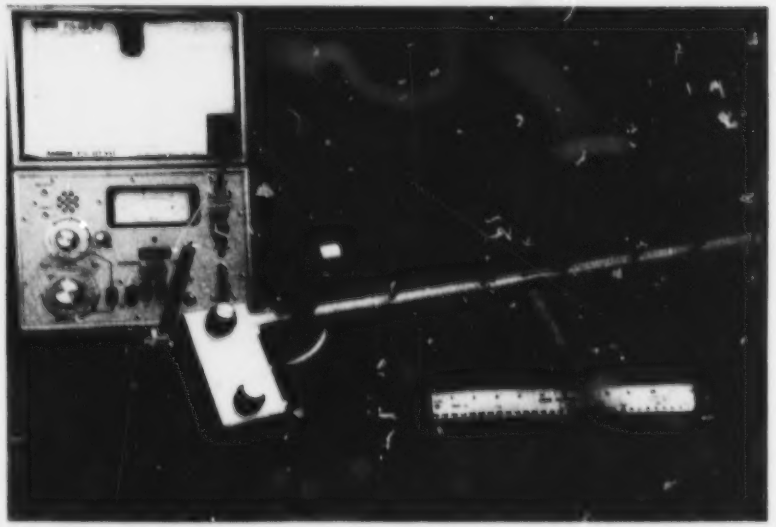


Micro Tech Interference Locator Model 700
and Model 544 Folded Dipole Antenna



Rohde & Schwarz Miniport Receiver Model EB100 and
Active Directional Antenna Model HE100

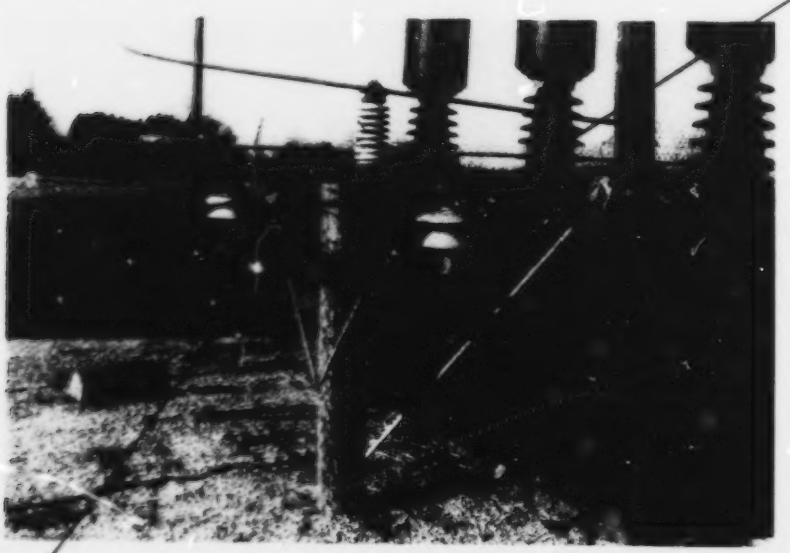
Radar Engineers Hotstick Line Sniffer Model 247



Sadelco FS 3D-VU Signal Level Meter and
Radar Engineers DDF Locator Model 297

Figure 3 TVI Instrumentation

Noisy insulator: sparking between tie wire and porcelain surface due to inadequate semi-conducting O-glaze



Artificial gap source: isolated tungsten tips (.102 mm gap spacing) and capacitively charged metallic sphere

Test voltage: 27 kV line-to-ground

Figure 4 Cross Arm Pole Structure
With Artificial Noise Sources

Distribution

Mr. G.E. Fraser	Manager, Distribution Operations, U6A6
Mr. W.T. Miller	Manager, Planning & Design, U5A4
Mr. C. Altomare	Distribution Operations, U6B1
Mr. M.S. Tibensky	Dist Planning & Design, U5A3
Mr. D. Jendek	Dist Planning & Design, U5B3
Mr. E. Derencinovic	P&C Telecom, U9A4
Mr. J. Holt	P&C Telecom, U9A4
Mr. R.E. Edwards	Manager, Dist Systems Central Rgn
Mr. H.J. Walton	Manager, Operations, Central Rgn
Mr. D.M. Miller	P&C Supt, Central Rgn
Mr. J.A. Dixon	Telecom Supervisor, Central Rgn
Mr. K.A. Osmars	Distribution Lines Supt, Central Rgn
Mr. F. Rimmer	Transmission Lines Supt, Central Rgn
Mr. D.J. Mills	Manager, Dist Systems, Eastern Rgn
Mr. V.J. Lynch	Manager, Operations, Eastern Rgn
Mr. R.T. Anderson	Supt - Operating, Prot & Control, Eastern Rgn
Mr. W.E. Smith	Telecommunications Supervisor, Eastern Rgn
Mr. G.O. Davidson	Mgr - Dist Syst & Operations, Georgian Bay Rgn
Mr. P.M. Richards	Lines Supt, Georgian Bay Rgn
Mr. B.C. Mitchell	Prot & Control/Operating Supt, Georgian Bay Rgn
Mr. R.H. Darch	Communications Supervisor, Georgian Bay Rgn
Mr. S.A. Money	Manager, Dist Systems, NE Rgn
Mr. D. Tegart	Distribution Lines Supt, NE Rgn
Mr. G.S. Graham	Manager - Operations, NE Rgn
Mr. C.A. Neal	P&C Supt, NE Rgn
Mr. R.N. Savage	P&C Tech Supervisor - Comm, NE Rgn
Mr. J.A. Mitchell	Manager, Dist Systems, NW Rgn
Mr. W.A. Ryan	Dist Lines Supervisor, NW Rgn
Mr. S.R. Roulston	Dist Lines Supervisor, NW Rgn
Mr. W.J. Buitenhuis	Manager - Operations, NW Rgn
Mr. G.B. Lomenda	Operating & P&C Supt, NW Rgn
Mr. W.M. Fraser	Mgr - Dist Systems, Western Rgn
Mr. D.G. Urquhart	Lines Operations Supt, Western Rgn
Mr. B. Ciccotelli	Dist Eng Supt, Western Rgn
Mr. J.F. Wicks	Manager - Operations, Western Rgn
Mr. F.W. Midwood	Operating & P&C Supt, Western Rgn
Mr. R.K. Trampleasure	Comm Supervisor, Western Rgn
Mr. A.F. Baljet	Electrical Research
Mr. D.C. Lee	Electrical Research
Mr. G.K. Hatanaka (2)	Electrical Research

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